Annual Report

Selective response of precipitation to temporally and spatially varying forcing of snow and soil moisture (GC03-322)

Project period: May 2003 – April 2006
Report period: May 2003 – April 2004
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1. Project description

This project aims at understanding the impact of the variability in land surface forcing on the variations of North American precipitation, in particular, the *selective* response of precipitation to temporally and spatially varying snow and soil moisture forcing. Work is conducted using the Eta Regional Climate Model, NCEP LDAS Data, NCEP Regional Reanalysis, U.S. Unified Daily/Hourly Precipitation Data, NCEP/NCAR Global Reanalysis, and others. Specifically, the project addresses the following questions:

(a) If snow and soil moisture can be specified to represent different timescales, how will precipitation vary correspondingly?
(b) Will the monthly-seasonal means of precipitation be affected by the change on timescales (e.g., from diurnal cycle to others) of snow and soil moisture forcing?
(c) If snow and soil moisture can be specified to represent different spatial scales, how will precipitation vary correspondingly?
(d) How will the snow and soil moisture in a region affect the variability of precipitation in a larger region?
(e) How will the changes in temporal and spatial scales of snow and soil moisture affect the roles of forcing initialization and memory in precipitation variability?
(f) How are the above features different between dry and wet regions, and between dry and wet seasons?

2. Work proposed for the report period (May 2003 – April 2006)

<u>(a) Analyses of observations and preparations for model experiments</u>
Analyze observational data (temperature, precipitation, atmospheric circulation, and others) for later verifications of model simulations.
For soil moisture and snow from the NCEP LDAS data, construct the hourly data into 3-hourly, 12-hourly, daily, weekly, and monthly means, and construct the original grid data into 4x, 8x, and 16x grids. These are the forcing functions of future model experiments.

<u>(b) Control experiments with Eta model</u>
Carry out five-member ensemble control experiments with the Eta model.
For soil moisture and snow from the model output, construct 3-hourly, 12-hourly, daily, weekly, and monthly means, and the means of 4x, 8x, and 16x grids, in a way similar to (a). These are the forcing functions of future model experiments.

<u>(c) Eta sensitivity experiments: Forced by assimilated snow and soil moisture</u>
Carry out five groups of experiments, each containing five ensemble members, using the various forcing functions developed from the NCEP LDAS in (a). This task will be continued in the second year (May 2004 – April 2005).

3. Accomplishment during the report period (May 2003 – April 2004)

(a) Analyses of observations and preparations for model experiments

We have analyzed several data fields including the temperature, precipitation, and atmospheric circulation for January-September of 1988 and 1993. Our purposes are twofold: to understand the different features between these dry and wet years and to verify model simulations. The NCEP Global Reanalysis and U.S. Unified Daily/Hourly Precipitation Data have been analyzed. Features in the NCEP Regional Reanalysis will be explored soon.

For this task, major effort has been devoted into the analysis of the NCEP LDAS data. We have examined the temporal (including the diurnal cycle) and spatial variations of the soil moisture and snow in the dataset. From the original hourly data in 1/8-by-1/8 grids, we have computed the 3-hourly, 6-hourly, 12-hourly, daily, weekly, and monthly means, the temporally-varying forcing functions for later model experiments. Similarly, we have constructed the spatially-varying forcing functions by redistributing the data into 4x, 8x, 16x, and 32x grids, respectively. We have compared the differences in temporal and spatial features among the various forcing functions (e.g., Fig. 1) and examined the diurnal cycle of soil moisture and snow in the NCEP LDAS data (see Fig. 2). It can be seen from Fig. 1, which shows the soil moisture for 1 July 1988 and 1 July 1993 (respectively) along longitude 107ºW, that substantial spatial features exist between the original and 8x grids. These features are believed to cause different response in precipitation. Figure 2 shows the diurnal cycles of soil moisture for January 1988 (a), July 1988 (b), 10 January 1988 (c), and 10 July 1988 (d). It also presents the variability associated with the annual cycle in 1988 at the point 35ºN/90ºW. The annual cycle of the soil moisture is roughly equivalent to 5-10% of the total values in the layer from the surface to 10 cm.

(b) Control experiments with Eta model

We have carry out five-member ensemble control experiments with the Eta model for 1988 and 1993, from December-January to September for each year. The results have been analyzed and will be compared with those from the various "sensitivity" experiments conducted later. It should be pointed out that the Eta has not been integrated previously for such a long period as done in the project. Substantial work has been conducted in testing the model.

As in (a), we have examined the temporal (including the diurnal cycle) and spatial variations of the soil moisture and snow from the model output. We have constructed the 3-hourly, 6-hourly, 12-hourly, daily, weekly, and monthly means, the temporally-varying forcing functions for later model experiments. Similarly, we have constructed the spatially-varying forcing functions in 4x, 8x, 16x, and 32x grids. We have compared the differences in temporal (including the diurnal cycle) and spatial features of soil moisture and snow among the various forcing functions from the model output. We have also compared the model output with the NCEP LDAS data (for soil moisture and snow) and with the NCEP Global Reanalysis and U.S. Unified Daily/Hourly Precipitation Data (for precipitation, temperature, and atmospheric circulation). Figures 3-4 are some snapshots of the results simulated by the Eta model analyzed from observations for February and June of 1993 (850-mb winds in Fig. 3 and precipitation in Fig. 4). As proposed previously, the results will be analyzed thoroughly, in comparison with those from the various sensitivity experiments, in the second year.

(c) Eta sensitivity experiments: Forced by assimilated snow and soil moisture

We are working on the technical issues about inserting the forcing functions of soil moisture and snow developed from the NCEP LDAS in (a) into the Eta model. After this, the ensemble experiments can be carried out easily as done in (b). As stated in the proposal, this task will be continued in the second year (May 2004 – April 2005) of the proposal period.

4. Publications

As indicated in the proposal, no publications have been previously planned for the first year, during which efforts are mainly devoted into model preparations and experiments.

5. Meetings

GAPP PIs Meeting, 21-25 July 2003, Seattle, WA (Presentation: Selective response of U.S. precipitation to temporally-spatially varying forcing in snow and soil moisture)

A number of meetings in NCEP Eta model group, and among CPC and EMC scientists

6. Plan for the next year (May 2004 – April 2005)

(a) Eta sensitivity experiments: Forced by assimilated snow and soil moisture

Carry out five groups of experiments, each containing five ensemble members, using the various forcing functions developed from the NCEP LDAS in 2(a). This is a continuation of the work initiated in the first year (May 2003 – April 2004)

(b) Diagnostics of Eta experiments forced by assimilated snow and soil moisture

Analyze model output from task (a). The major features of the proposed study will be studied here and the results will be presented to various meetings and published in professional journals.

(c) Eta sensitivity experiments: Forced by modeled snow and soil moisture

Carry out five groups of experiments, each containing five ensemble members, using the various forcing functions developed from the Eta experiment output in 2(b).

7. Contacts

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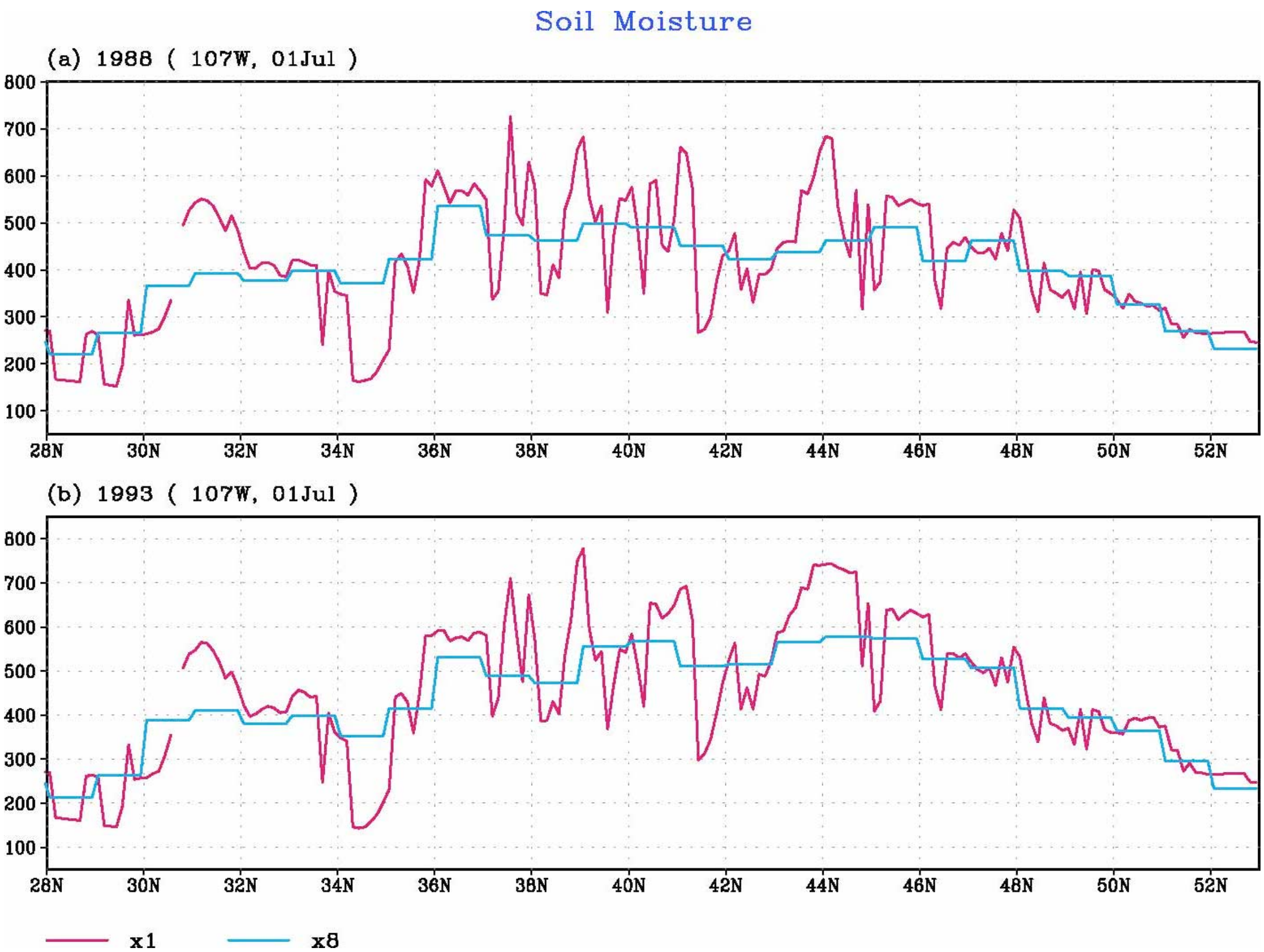

Fig. 1. (a) NCEP LDAS soil moisture of 1 July 1988 along 107°W for the original grids (0.125°x0.125°; red) and for the 8x grids (1°x1°; blue). (b) Same as (a) but for 1 July 1993. Unit: mm.

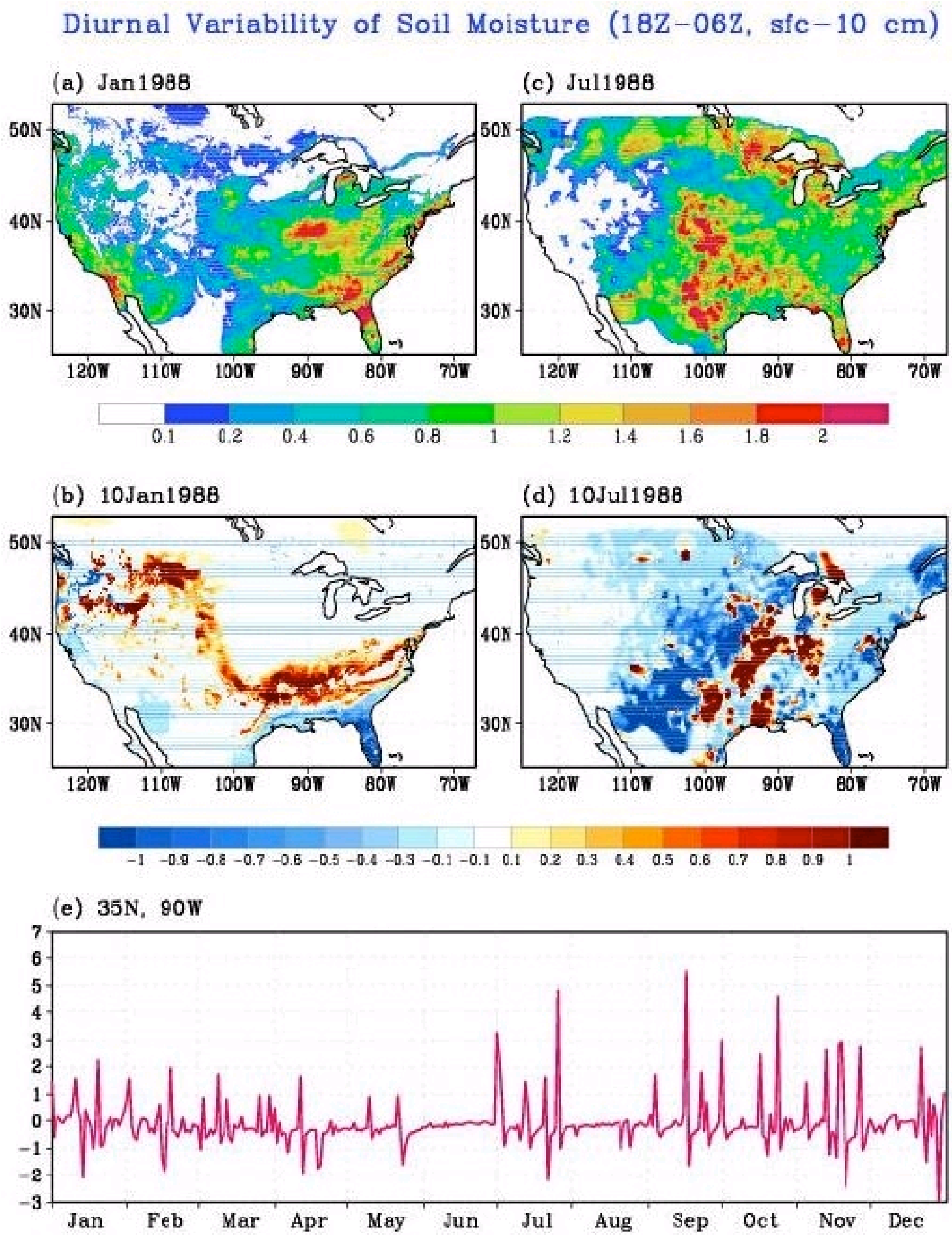

Fig. 2. Diurnal variability (18Z-06Z) of soil moisture in the top layer (surface – 10 cm) for January and July 1988 (a and c) and for 10 January and 10 July 1988 (b and d). Also shown in (e) is the diurnal variability of soil moisture in 1988 at the point 35ºN, 90ºW. Units: mm.

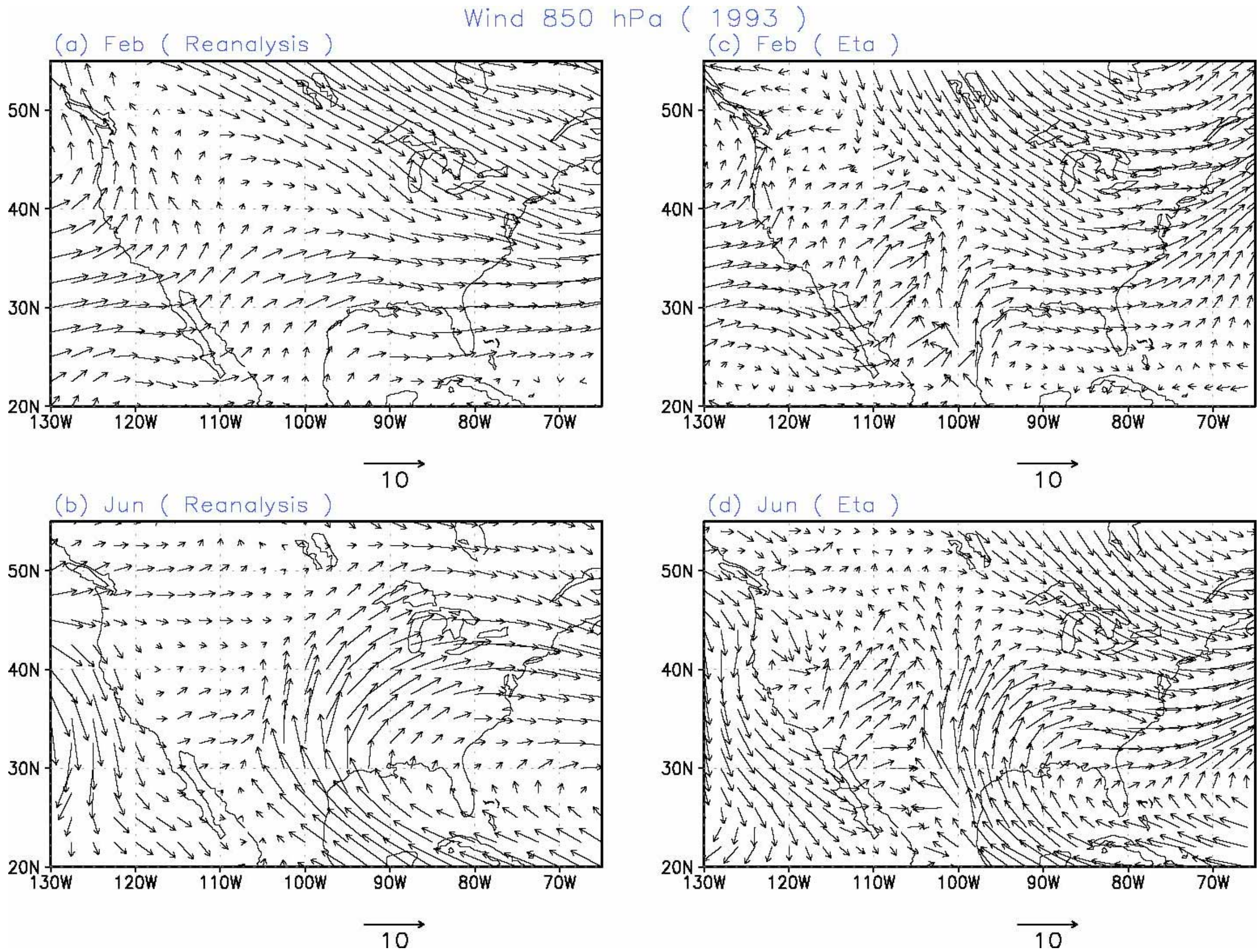

Fig. 3. Monthly means of 850-mb winds for February and June 1993 from the NCEP/NCAR reanalysis (a-b; ms^{-1}) and from the 5-member ensemble means simulated by the Eta model (c-d).

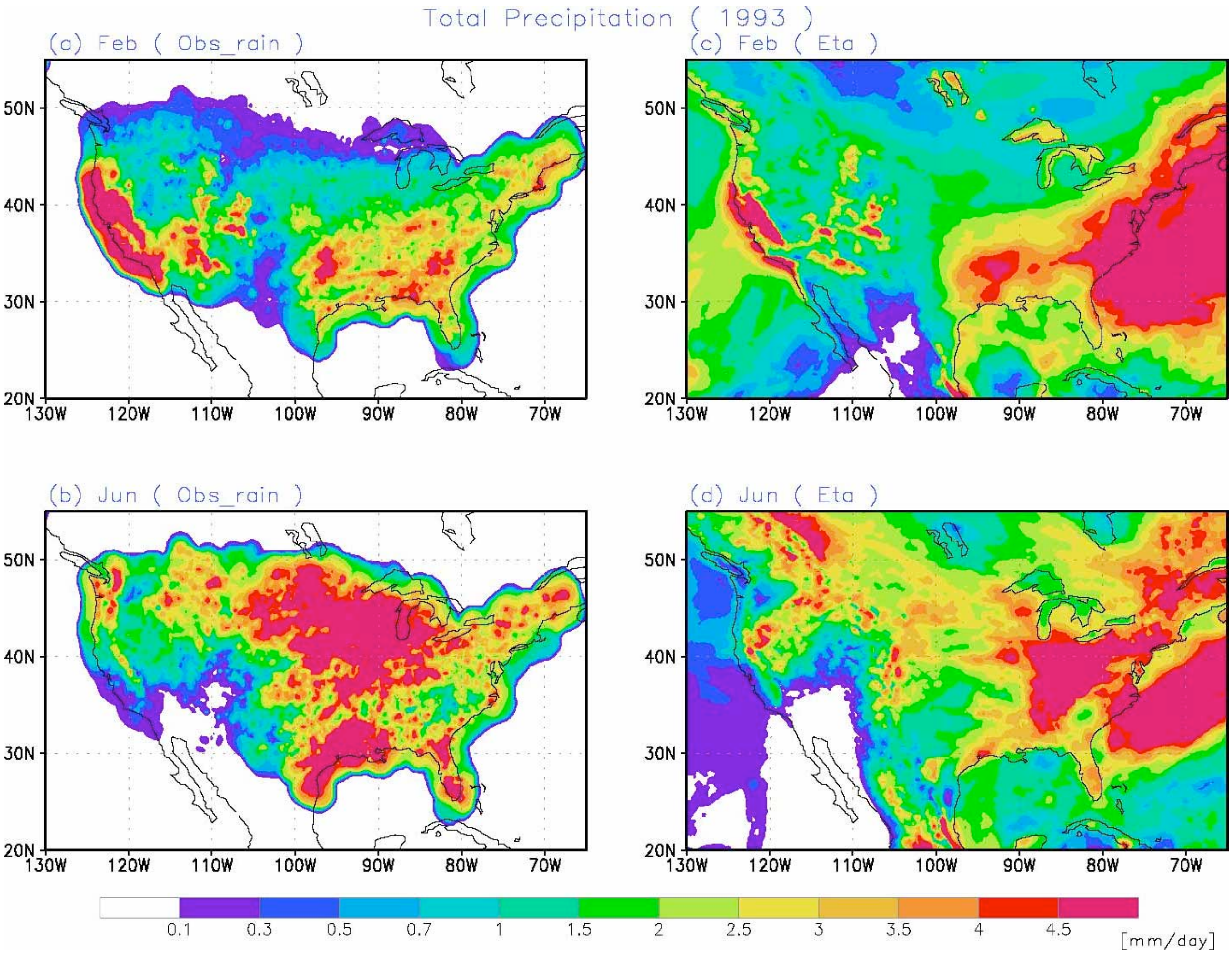

Fig. 4. Monthly means of precipitation for February and June 1993 from the U.S. Unified Daily Precipitation Data, (a-b; mm per day) and from the 5-member ensemble means simulated by the Eta model (c-d).